Composting Treatment of Contaminated Soil and Sediment

U.S. EPA Test and Evaluation Facility Research Project

Bench-scale compost reactor system

Project Objectives:

The objectives of this Work Assignment are to:

1. Evaluate the potential use of a compost system in the bioremediation of soil or sediment contaminated with polynuclear aromatic hydrocarbons (PAHs).

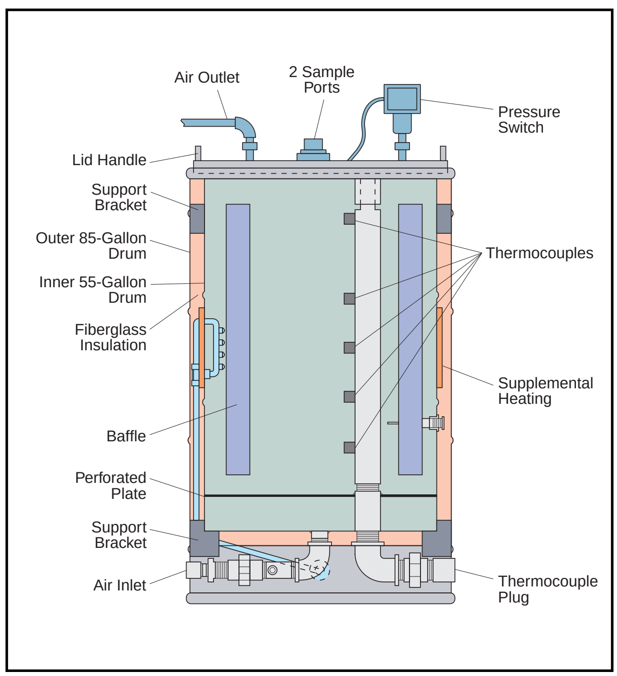
2. Conduct treatability studies using soil or sediment contaminated with PAHs in bench-scale closed-vessel composting systems.

3. Collect data to optimize operating conditions and understand the mechanisms of hazardous chemical transformation occurring in compost systems.

Environmental Relevance:

Composting is a process by which organic materials are biodegraded by microorganisms, resulting in the production of organic and/or inorganic by-products and energy in the form of heat. In the compost treatment process, contaminated soil or sediment is blended with nutrients and one or more bulking agents and placed in a compost reactor (or a compost pile) for a specified period of time. Oxygen is supplied to the compost through a system of piping that either forces air into the compost (a positive-pressure system) or pulls air through the compost (a negative-pressure system). Various species of bacteria in the compost utilize the available carbon sources and, in the process, biodegrade the organic contaminants.

Composting treatment holds the potential to serve as a low-cost method of treating hazardous waste with minimal environmental controversy; however, information is lacking regarding the treatability of various toxicants and optimum conditions for treatment. Optimal application of biotechnology to large-scale compost systems is based on a working understanding of processes and mechanisms involved in composting of organic materials. Currently, commercial compost operations are operated as "black-box" systems where optimization is largely achieved through trial and error. Thus, optimal controls are required to meet the specified endpoints in the large-scale treatment of hazardous waste.



Schematic of a bench-scale compost reactor

Experimental Approach:

Twelve bench-scale compost reactors have been designed to demonstrate appropriate process parameters for treating contaminated soil or sediment. This research includes identification of suitable bulking agents (e.g., corn cobs, rabbit chow, perlite, hay, straw), appropriate ratios of soil or sediment to bulking agents, and effective aeration strategies and rates. Careful progression from bench-scale and pilot-scale to large-scale operations may permit development of closely controlled experiments for reliable data collection on mechanisms of metabolism and fate of toxic chemicals during soil or sediment composting.

The bench-scale compost reactor consists of a 55-gallon stainless steel inner drum that is welded, sealed, and insulated within an outer 85-gallon drum to prevent heat loss during the composting process. In the center of the inner drum, five thermocouples, installed vertically, measure the temperature of the compost as well as the headspace above the compost. A personal computer monitors and records the temperature of the compost. A band heater, mounted around the inner drum, provides supplemental heating to the compost reactors.

A perforated plate, located 6 inches above the bottom of the composter, suspends the compost over the air inlet and provides even air distribution to the compost. Air flow to the compost is provided by the T&E Facility high-pressure air system. During typical operation, low air flow is used to aerate the compost. However, if the temperature of the compost rises above the desired setpoint, high air flow is automatically activated to lower the compost temperature. Flow meters are installed on the inlet of each compost reactor to measure the air flow rate.

The compost reactors may be placed on a conveyor belt located alongside each bank of 6 composters and rolled for a short time to mix the reactor contents and eliminate anaerobic air pockets. Two baffles are welded to the inside wall of the compost reactors to aid in mixing the compost mixture when the drums are rolled.

Samples of the compost mixture for chemical and physical analyses are collected through two 2-inch sample ports located on the top of the compost reactors. The moisture content of the compost mixture is adjusted by adding water to the compost reactors through the top sample ports. A leachate collection system is located at the bottom of each compost reactor.

The test sediment being evaluated under this project in FY1999-2000 originated from the Kinnickinnic River near Milwaukee, Wisconsin. Ten 55-gallon drums of sediment were received at the T&E Facility, and the sediment in the drums was homogenized. The homogenized sediment was then passed through a ½-inch screen to reduce the maximum particle size. The screened sediment was then mixed with the appropriate nutrients and bulking agent. For this study, Fenton's reagent (a combination of ferrous sulfate and hydrogen peroxide) is being added to several compost reactors to study any enhancements due to chemical oxidation.

The treatability studies generally proceed for 12 to 16 weeks. During the sampling events, two samples are removed from each compost reactor and analyzed for PAHs. Contaminant reduction is evaluated for the different compost conditions over the course of the study period.

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